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Methods and tools for the assessment of urban sustainability

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Abstract

This dissertation was written as part of the MSc in Environmental Management & Sustainability at the International Hellenic University.

Sustainability has initially emerged as a designing perception in the fields of economics and ecological consideration whilst afterwards has also been applied to urban development. Sustainable urban development requires holistic performance and high responsibility towards local and global manners, regarding the three pillars of sustainability. Urban sustainability is considered to be a desirable status of urban conditions that constantly occur over time.

Equally to the significance of defining sustainability is the task of defining urban assessment process with its relevant methods and tools. Many assessment methods and tools can be identified from literature, attempting to evaluate urban sustainability. The assessment process of urban sustainability implies the existence of methods and tools to measure performance with respect to pre-established principles, guidelines, factors, or other criteria.

The present dissertation presents a thorough review of the sustainable development and urban sustainability. Its primary object is to provide a comprehensive overview of the existing methods and tools that can be applied by cities in a local or global scale, in order redefine their sustainability status, planning their future actions for further development.

At this point, I would like to thank Dr Georgios Banias and Dr Charisios Achillas for supporting and supervising the present dissertation, providing insight and expertise that greatly assisted the research. In addition, I would also like to show my gratitude to the International Hellenic University (IHU) and its professors, for sharing their knowledge regarding my Master of Science degree. Finally, I am personally grateful to my family that constantly supported me to successfully complete my master degree.

Keywords: Sustainability, Urban Sustainability, Sustainability Assessment, Methods and Tools, Sustainability Indicators

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Introduction

In recent years, the rapid growth of population's moving trend, from the countryside to urban conurbations, has resulted in the 50% increase of the global population that lives in such urban areas (Tartaglia et al. 2014). By 2050, the urban population is expected to increase even further to reach two-thirds of the world's population (Shen et al. 2011). Cities related activities are responsible for 70% of greenhouse gas emissions, as well as the depletion of agricultural land and natural resources. This is mainly due to the excessive consumption of energy and resources, waste management, sewage and transportation systems. As a result, such factors threaten the balance of the three pillars of urban sustainability: the economy, the environment and society.

The necessity for integrated methodological frameworks for assessment of sustainability, in quantifiable and measured terms, has been widely discussed in the past (Gibson et al. 2006, Ness et al. 2007, Hacking and Guthrie et. al. 2008, Yigitcanlar et al. 2015). The majority of the scientific community insists on the necessity to find solutions to recreate a sustainable environment that offers healthy places to live in urban areas and that accomplishes a balance between humans and the ecosystem. There also needs to be respect for nature because it is the main source of energy and resources that offer solutions to the contemporary and future city (Sharifi et al. 2013).

The sustainability of each urban design element can achieve the required balance collective actions, leading into creating urban design sustainability (Turcu et al. 2013). Consequently, cities have become the main player in urban sustainability. It has been have confirmed that the assessment of urban sustainability requires a comprehensive and integrated view of the city and its miscellaneous parts (e.g. population, mobility, transportation, land use, urban spaces, water use, energy use, geographical diversity, air quality, etc.). All these components represent the basis of the evaluation of urban sustainability (Gil and Duart et al.2013, Haapio et al. 2012, Mourshed et al. 2005).

1. Sustainability

The world's increasing trend towards global population urbanization will continue its constant proceed in the near future. Starting in 1800, only 2% of the world population lived in cities but since then, a sharp increase was monitored up to 50%, reaching 2008 (Wu et al. 2014). As a result, by 2050 the world population is expected to be 70% urban and by 2092 roughly 100% (Batty et al. 2011). Although urbanization could have a positive effect on socioeconomic development, can also have various effects on the environmental quality and performance of the cities (Grimm et al. 2008, Pickett et al. 2011, Liu et al. 2014, Wu et al. 2014).

Since the 1970s, the concept of sustainability was related to the fast growth of the world population, accompanied with environmental degradation and increasing concerns for the reduction of natural resources. In 1972, at the United Nation Conference in Stockholm, the main subject was the constant development both for the environment quality and performance, and the quality of the living conditions of the world's poverty population.

In 1987, the Brundtland Commission (Brundtland 1987), known in the past as the World Commission on Environment and Development (WCED), provided the first definition of sustainable development, having great impacts on various stakeholders such as policy-makers, scientists, citizens, and economists. "The development that meet the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987) is a definition for sustainability that challenged the traditional ways of planning and designing future actions in order to achieve further development, supporting scientists and design-makers to clarify that human activities and interactions with its surroundings lead to significant environmental, social and economic impacts. In addition, such first attempt of report contained two key concepts: i) the "needs" concept, demonstrating effectively all the important needs that the world's poor population has and ii) the "limitations" concept, describing how the evolution of technology and various social organizations enhance the environment's capability to fulfill present and future needs.

From a series of reports, including the one resulting from the Rio Summit (UNCED 1992, Mitchell et al. 1995), four principles were identified, beside the environmental aspects that such a sustainable development might affect. Those four principles are: equity, futurity, environment, and public involvement. The protection of the environment and a well-structured environmental strategy constitute main priorities of any sustainability process. However, having such targets can only be accomplished via collaborative decisions, transparency procedures with directed guidelines and increased environmental principles, at a personal and global scale. As a result, every person individually and generally the entire world should act responsibly towards a sustainable future except for the policy-design makers.

Sustainability is a constantly flexible process rather than a permanent and unchangeable condition. According to the U.N. World Commission on Environment and Development: "Sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations" (WCED 1987). In addition, it is accepted that sustainability has "three pillars" or "three dimensions"- environment, economy, and society (known also as the "Triple Bottom Line").

1.1 Time line of sustainability

From its beginnings, approximately the 1970s, sustainability or sustainable development has become one of the most controversial but also constantly and increasingly accepted principle of recent times. The United Nations, various international organizations and research institutions, having the agreement of societal scientists and design-policy makers, promote the vision and principles of sustainability. As a result, this led to a steadily increase of the acceptance and implementation of the principles of sustainable development, at a local or global scale. The Figure 1 demonstrates the timeline of growth of sustainability, which consists of the most paramount historical milestones in the history of urban sustainable development. Several recent attempts have been made to review the historic events and major scientific advances in sustainability research (Kates et al. 2001, Wu et al. 2013, 2014).

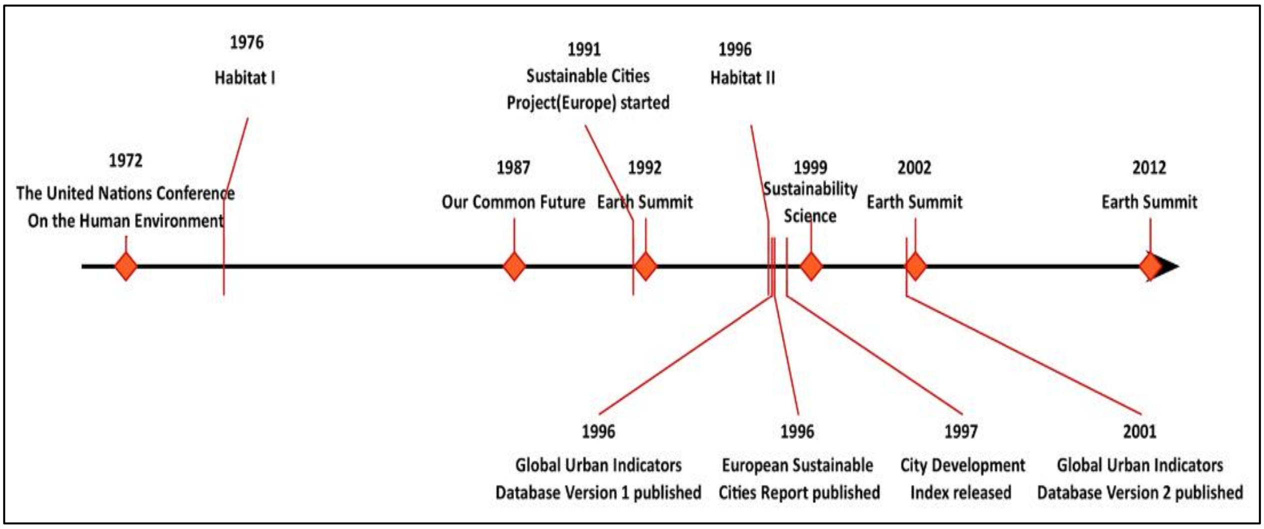

Figure 1: Timeline of important events in the history of urban sustainable development (Huang et al. 2015).

From its beginning until now, the timeline of growth of sustainable development consists of the most paramount historical milestones, which are depicted also in the previous figure, are the following (Huang et al. 2015):

(i) In 1972 United Nations Conference on the Human Environment, when the international community attempted for the first time to discuss and define the global environmental and development challenges.

(ii) In 1987 Brundtland Report (WCED 1987), creating the most globally known and used definition of sustainable development.

(iii) In 1992 Rio Earth Summit, which endorsed the Rio Declaration and Agenda 21, requesting for the development of sustainability indicators.

(iv) In 1999 US National Research Council Report (NRC 1999), which invented the expression “Sustainability Science”.

(v) In 2002 Johannesburg Earth Summit that confirmed the performance of Agenda 21.

(vi) In 2012 Rio20 Earth Summit and the 2017 Paris Climate Conference, which promote ways to increase the implementation of sustainability’s principles.

1.2 Urban Sustainability

The main concentration of sustainable development regarding the development of the cities has led to urban sustainability, becoming more and more discrete on political agendas and scientific investigations. In 1976, four years after the 1972 United Nations Conference on the Human Environment, was held in Vancouver, Canada, the first United Nations Conference on "Human Settlements (Habitat I)". Afterwards, in 1991, the European Commission introduced the "Sustainable Cities Project". In 1992, it was established the "Sustainable Seattle", the worldwide-known community concerning global urban sustainability projects. In 1996, the second United Nations Conference on "Human Settlements (Habitat II)" was held in Istanbul, Turkey. In the same year, the European Commission published, for the first time, the European Sustainable Cities Report, communicating the already made efforts and the future visions/goals for supporting sustainability in European urban areas. (Shen et al. 2011, Wu et al. 2014).

Furthermore, urban sustainability has already been defined in different approaches, with different weighting criteria and focuses. Such various approaches affected also the creation and the selection of urban sustainability indicators. As a result, the main definitions of urban sustainability focus on the continuous progress of human wellbeing through the balance of the three dimensions of sustainability, the minimization of the consumption of existing resources and the environmental degradation and finally the maximization of efficiency use of resources. For example, "the European Environment Agency set five urban sustainability goals in 1995 as follows: i) minimizing the consumption of space and natural resources, ii) rationalizing and efficiently managing urban flows, iii) protecting the health of the urban population, iv) ensuring equal access to resources and services, v) maintaining cultural and social diversity" (Stanners and Bourdeau et al. 1995).

The United Nations Centre for Human Settlements (Habitat 1997) defined a sustainable city as "a city where achievements in social, economic, and physical development are made to last and where there is a lasting supply of the natural resources on which its development depends" (Huang et al. 2015). The definition that was given by Munier (2007) presents mainly the efforts of local communities to enhance the participation of urban citizens towards sustainability, explained as: "A sustainable city is one in which the community has agreed on a set of sustainability principles and has further agreed to pursue their attainment" (Huang et al. 2015).

Recent urban sustainability studies present an increasing trend on focusing in the relationship between the quality of environment and human wellbeing (Wu et al. 2010; Elmqvist et al. 2013; Nassauer et al. 2014; Wu et al. 2014). Urban sustainability is defined by Wu (2014) as “an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human wellbeing through concerted ecological, economic, and social actions in response to changes within and beyond the urban landscape” (Wu et al. 2014).

In recent years, it is obvious that there has been made great progress towards the evolution of sustainable development and its assessment processes. Thus, there is a wide variety of processes, comprising methods, tools and indicators, for the sustainability assessment. However, selecting the most suitable assessment process could lead to further improvement of sustainable development while also contribute to successful outcomes of such development.

2. Sustainability Assessment

2.1 Introduction to Sustainability Assessment

Sustainable development plays a crucial role on decision-making strategy, assisting the decision-makers with the most suitable tools in order to modify the existing urban conditions, achieving the highest possible urban development and also illustrating the main difficulties and obstacles that in such a strategy the role of sustainability is the key. Therefore, based also on the works of Devuyst et al. (2001), Gasparatos et al. (2008), Gibson et al. (2005), Ness et al. (2007), Pope (2006), and Bond et al. (2012), sustainability assessment is defined as follows:

Sustainability assessment is any process, which is primary object is to:

- Clarify the meaning and benefits of sustainability, providing a comprehensive interpretation.
- Integrate the sustainability's concerns into decision-making process by monitoring and communicating the impacts of sustainability.
- Promote and support the sustainability's visions and goals.

The term sustainability refers to a particular relationship between the quality of environment and human wellbeing, which aims to fulfill human needs in the long term (WCED 1987). The main concern relies on how much the manufactured capital could be invested in natural capital. However, there is an argument between some neoclassical economists and ecologists, since the economists' point of view support short-term changes while ecologists point that some changes are doubtful for some essential systems. According to Pezzey (1992), sustainability is "non-declining utility", which occurs by aggregating the stocks of natural and artificial capital. In comparison, the Second Strategy for Sustainable Living presents the concept of sustainability as a steady progress for enhancing human wellbeing while living within the existing ecosystems (IUCN 1991). Ecological economist Herman Daly (1991) "suggests three criteria to assess sustainability:

- Rates of use of renewable resources do not exceed replacement rates.

- Rates of use of non-renewable resources do not exceed rates of development of renewable substitutes.
- Rates of pollution emissions do not exceed the assimilative capacity of the environment" (Daly et al. 1991).

Nevertheless, applying sustainability ensures the fulfillment of human needs without depleting the local and global resources while creating unsustainable conditions. However, cities may plan their actions towards sustainability, reaching the main targets of it at a local scale, without necessarily being sustainable at a global scale. Concerning short terms point of view, cities could contribute to accomplish better local environmental conditions by re-planning unsustainable factors. On the other hand, concerning long term point of view, it could become clear the connection between local quality and global sustainability. As a result, the same cities that successfully achieve better local quality could be affected by global environmental problems such as climate change, acidification, stratospheric ozone depletion etc.

2.2 Object of sustainability assessment

The primary object of any urban sustainability assessment process is to provide the essential tools for comprehensive decision-making changes, re-designing policies and plans regarding matters of urban development. In addition, one basic requirement of all urban sustainability assessments processes is to clarify and communication the connection of economic, social and environmental factors within actions, legislations and projects both at local and global scale.

Furthermore, sustainability assessment process could assist in a decision-making strategy for sustainable development. Therefore, there are four main goals, which contribute to support such sustainability decision-making modifications:

- Creation of essential outcomes and information to support decision-makers.
- Promotion for social participation and open discussions.
- Social education towards sustainability knowledge and attitude.
- Organization of the complexity of generated information.

Firstly, sustainability assessment provides all the essential information for decision-makers, through transparent procedures, having investigated the best available knowledge of local and global potential sustainability impacts. As a result, every sustainability assessment process promotes conditions and alternative opportunities, which lead to choose among different alternative choices, in terms of sustainable development (Bond et al. 2012).

Secondly, sustainability assessment promotes the meaning of sustainable development in a given framework concerning social and environmental issues, assisting various debates, and supporting and organizing the participation of different groups of stakeholders (Baber et al. 2004, Bebbington et al. 2007).

Thirdly, "sustainability assessment is a learning process that can lead to a shift in the involved stakeholders'/decision-makers' sustainability knowledge, attitude and views" (Nooteboom et al. 2007). As a result, pre-decision discussions contribute to new visions and goals (Bell and Morse et al. 2008), generating conditions for better changes regarding the decision-making process.

Fourthly, sustainability assessment organizes the complexity of information, demanding the available tools to achieve such structuring process. Therefore, sustainable assessment procedure assists decision-makers to deal with the complexity of available information towards sustainable development.

2.2 Background of sustainability assessment

In the recent years, there is a constant increasing progress towards the evolution of assessment methodologies that attempt to evaluate the impact of development concerning urban areas. However, until nowadays, there is a lack of sufficient understanding regarding the interactions of social, economic and environmental factors of sustainability. Furthermore, the absence of integrated urban sustainability assessment methods is demonstrated by various reports on sustainability assessment methods.

However, urban infrastructure has extended, causing various impacts on sustainable development of its area. Therefore, the establishment of sustainable urban infrastructure has its primary object, which is to prevent any unnecessary consumption of natural resources and to mitigate any hazardous emissions. Moreover, in accordance with the "Triple Link Sustainability" model (Howes et al. 2005), "every project may be evaluated in terms of environmental, economic and social aspects of sustainability (Camagni 1998), where integration and optimal balance of all three dimensions and objectives is needed for overall sustainability" (Figure 2) (Zevrl et al. 2010).

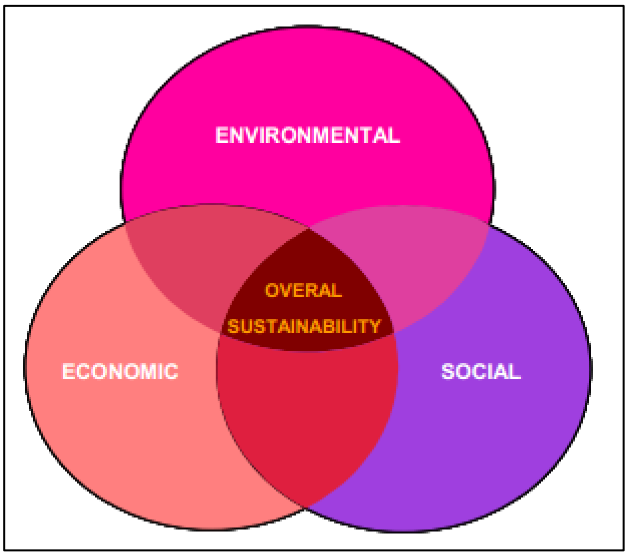

Figure 2: The three basic dimensions of sustainability (Zavrl et al. 2010).

2.3 Assessment methods and tools

In recent years, there is a wide variety of different assessment methodological processes to monitor and fulfill the various purposes of sustainability assessment. Starting in 1996, the "Bellagio Principles - Guidelines for Practical Assessment of Progress towards Sustainable Development" was developed, while its principles functioned as common guidelines for sustainability assessment (Pinter et al. 2012, Hardi et al. 1997). Afterwards, the project of the Bellagio Principles was reviewed and renamed as "Sustainability Assessment and Measurement Principles" ("Bellagio STAMP") (Pinter et al. 2012).

The following Table 1 presents all the fundamental characteristics of a typical sustainability assessment method, which are developed and summarized by the Bellagio Principles, Bellagio STAMP and general scientific literature (Gibson et al. 2006, Bond et al. 2012, Lee et al. 2006, Huge et al. 2011). "Such characteristics are classified in four categories: i) Fostering sustainability objectives, ii) Adopting a holistic perspective, iii) Incorporating sustainability in the assessment process and iv) Supporting decisions" (Waas et al. 2014).

Table 1: Characteristics of a typical sustainability assessment method (Waas et al. 2014).

1. Fostering sustainability objectives	• Intergenerational equity • Intragenerational equity • Geographical equity • Interspecies equity • Procedural equity
2. Adopting a holistic perspective	• Assess the system as a whole, including it parts and their interactions • Assess the system considering the different sustainability objectives together (integration) • Assess dynamics and interactions between trends and drivers of change • Adopt appropriate time horizon (short, medium, and long term) and (geographical) scope
3. Incorporating sustainability in the assessment process	• Consider the normative nature of sustainability • Broad participation of stakeholders, including experts, while providing active leadership to the process • Transparency regarding data (sources, methods), indicators, results, choices, assumptions, uncertainties, funding bodies and potential conflicts of interest • Avoid irreversible risks and favors a precautionary approach • Be responsive to change, including uncertainties and risks (dynamism)
4. Supporting decisions	• Assessment of sustainability impacts and alternatives for decision-making, including synergies and trade-offs • Establish formal and transparent synergy/trade-off rules • Assessment is based on a conceptual sustainability framework and its indicators • Ensure effective communications (clear language, fair and objective, visualization tools and graphics, make data appropriately available) • Adapted to and integrated into the institutional context • Iterative assessment process, starting at the onset of the decision-making process • Develop and maintain adequate capacity • Continuous learning and improvement

To begin with, defining principles of sustainable development contributes to guidance every sustainability assessment process. As a result, sustainability principles ensure the sustainability assessment's content, enforce the goals and visions of sustainability with a comprehensive perception, while the operational process is characterized by its transparency way with awareness to expected evolution and changes. Secondly, each sustainability assessment process is directly associated with the support of decision-making. Therefore, suggested guidelines accompany the assessing process of any sustainability method, clarifying and communicating impacts and alternatives plans for decision-making changes (Gibson et al. 2009).

Furthermore, sustainability assessment depends on a theoretical sustainability framework accompanies with its relevant indicators, providing effectively any communications. Also, every sustainability assessment method implies a comprehensive defined assessment process, retaining its sufficient quality and promoting constant learning and development (Waas et al. 2014). The Table 1 summarizes and presents the characteristics of an ideal-typical sustainability assessment method.

In addition, a wide variety of methods and tools (see Appendix, Table I and Table II) is available to evaluate the sustainability of projects concerning urban infrastructure. However, the tools present differences in: i) the scope and content, ii) the way they assess the values of essential indicators and iii) the communication and explanation of the outcomes. The majority of such tools concerns specifically categories of urban infrastructure projects. Therefore, in the literature review, there is a wide variety of studies that present comparisons of methods and tools for sustainability assessment regarding buildings and neighborhoods, there are other that communicate all the three pillars of sustainability (Karol et al. 2009, Haapio et al. 2008, Xing et al. 2009), whilst others remain in environmental concern, like the LCA method (Life Cycle Assessment) (Khasreen et al. 2009, Bribia et al. 2009).

The following Table 2 presents some of the existing assessment methods with a suitable evaluation method, for urban infrastructure, accompanied with economic, social and environmental concerns. However, there are methods that are more appropriate for projects evaluation, such as the Environmental Impact Assessment (EIA), while there are others that are focus on dealing with strategic policy decision making, such as the Strategic Environmental Assessment (SEA). In addition, there are available methods such as Life Cycle Assessment (LCA) and Ecological Footprints (EF) that tend to be preferably used in cases of environmental concerns of sustainability, for example the building construction sector (Khasreen et al. 2009, Bribia et al. 2009) while the EF method is mainly used in cases of energy supply infrastructure projects (Stoglehner et al. 2003).

The main use of economic assessment methods like Cost-Effectiveness Analysis (CEA) and Cost Benefit Analysis (CBA) is mainly preferable in cases of defining the cost and benefits of urban projects (Riberiro et al.2008). However, in cases where monetary terms cannot sufficiently present the impacts of a project, the Multi-Criteria Analysis (MCA) is commonly used, facilitating decision-making while determining specific elements and indicators.

Table 2: Methods for the assessment of sustainability urban infrastructure (Zavrl et al. 2010).

Methods with an environmental focus
Environmental Impact Assessment (EIA)
Strategic Environmental Assessment (SEA)
Life Cycle Analysis (LCA)
Ecological Footprints (EF)
The Ecological Rucksack (ER)
The Green Poster (GP)
Methods with an economic focus
Cost-Effectiveness Analysis (CEA)
Cost Benefit Analysis (CBA)
Multi-criteria decisions aid (MCDA)
Environmental Accounting (EA)
Methods with a social focus
Social Impact Assessment (SIA)
Socio Economic Impact Assessment (SEIA)

Multi-criteria decision analysis (MCDA) is a type of MCA, invented for cases with complex monetary projects, which performs by separating firstly each project into smaller pieces and afterwards reassembling it to a final outcome for assisting the decision-makers (Belton et al. 2002). MCA functionality could be seen in cases for the evaluation of projects regarding the energy infrastructure sector. In addition, the sustainability assessment methods, which are more relevant to evaluate social elements of sustainability, are tend to be less frequent in use than the methods that have an environmental or economic concern.

3. Assessment Methods

3.1 Introduction to Assessment Methods

Sustainability's assessment methods are designed to fulfill specific sustainability targets, presenting the level of the environmental quality, evaluating the scale of a progress that has been made while assisting decision makers regarding present and future decisions and changes (Brandon & Lombardi et al. 2011). In addition, the evaluation process of every assessment method is commonly used to monitor the progress in accomplishing specific sustainable development goals.

There is a wide variety of assessment methods available but their classification can be a challenging process. Such available assessment projects are: the "Sustainability A - Test" EU project (see Appendix, Table II), the ECO2 Cities study, the LUDA project, and the BEQUEST project and others (Poveda et al. 2011).

Furthermore, the Sustainability A - Test EU project provides an inclusive assessment operating framework in which various sustainable development tools such as methodologies, approaches and appraisals are getting clarified and validated. The project includes different categories, as shown in Table II (Appendix): assessment frameworks, participatory tools, scenario analysis, multi-criteria analysis, cost-benefits analysis and cost-effectiveness analysis, modeling tools, accounting tools, physical analysis tools and indicator sets (Poveda et al. 2011).

The World Bank has invented the ECO2 Cities project to support cities worldwide in achieving greater sustainability regarding the pillars of environment and economy. The ECO2 Cities project develops a comprehensive operational framework, providing cities world-wide with the essential tools towards the accomplishment of their determined sustainable goals.

In addition, Suziki (2010) presents three different categories of assessment methods regarding the ECO2 Cities project. The ECO2 Cities assumes three basic categories of assessment methods: i) methods that help the cities to re-design decision-making processes, supporting the development cities' leadership and collaboration, ii) methods that help cities to examine and monitor flows and forms in order to clarify the developing linkages that occur between the cities (forms) and their natural environmental flows (energy consumption and emissions) and iii) methods that deal with planning evaluation, including accounting methods, life-cycle costs analysis, risk decrease and adaptation. Such methods assist cities not only to enhance their implementation of better strategic management and long-term decision making process (Poveda et al. 2011).

The LUDA (Large Urban Distressed Areas) is a research project of Key Action 4 - “City of Tomorrow & Cultural heritage” - of the program “Energy, Environment and Sustainable Development”, part of the Fifth Framework Program of the European Commission. LUDA project assists cities to develop and manipulate methods and tools towards their urban configuration, dealing with environmental, economic, and social impacts, enhancing simultaneously the quality of life (LUDA Project 2011).

Furthermore, the BEQUEST (Building Environmental Quality Evaluation for Sustainability) project includes a list of 61 assessment methods, tools and procedures. The BEQUEST project is used to provide the essential tools in order to support the process of urban sustainable development in every stage regarding planning, designing, construction and operation of the process. “BEQUEST integrates four dimensions of urban sustainable development: activity development, environmental and social issues, spatial levels, and timescale” (Poveda et al. 2011).

In 1987, after the presentation of the Brundtland Commission report “Our Common Future”, a wide variety of new assessment tools, such as methodologies, approaches, and appraisals became available. However, there were already existing methodologies before the Brundtland report like the cost-benefit analysis, contingent valuation, hedonic pricing method, travel-cost method, and multi-criteria analysis. In addition, other evaluation procedures were also established including tools such as EIA (Environmental Impact Analysis) and SEA (Strategic Environmental Analysis) (Poveda et al. 2011).

3.2 Environmental, Social and Economic Impact Analysis (EIA)

In 1969, the National Environmental Policy Act (NEPA) created the Environmental Impact Analysis (EIA, an assessment process that can be used to evaluate the degree of the potential impacts of a project. However, its primary object is to monitor all the environmental impacts and communicate them to stakeholders and decision-makers, supporting the decision-making process. In addition, the other two pillars of sustainability, social and economic factors, are examined similarly with their relevant issues, being included in an environmental impact analysis. The advantage of using the EIA assessment method is the capability that users have to take into consideration the various impacts during the decision-making procedure. However, there are limitations in areas of defining, examining, predicting and measuring possible impacts and also the use of particular methods and participation (Brandon & Lombardi et al. 2011).

3.3 Strategic Environmental Assessment (SEA)

Due to the fact that the Environmental Impact Analysis (EIA) can be applied to a specific project, the United Nations Economic Commission for Europe suggested the extension of EIA for policies, plans, and programs (PPP), which has led to the development of SEA (Strategic Environmental Assessment) project. Its main goal is to assist the decision-makers in early stages of any assessment process, certifying that decisions are made accurately and sufficiently. The main difference between the mentioned assessment methods of SEA and EIA is that the SEA focuses on developing policies, plans, and programs (PPP) at a superior level towards the decision-making procedure whilst EIA is primarily focused at the project level. Furthermore, SEA supports public's participation, promoting the engagement of the public in the decision-making process. Its main weakness is that it depends on time and the available resources whilst social and economic issues are usually excluded (Poveda et al. 2011).

3.4 Cost-Benefit Analysis (CBA)

A Cost-Benefit Analysis (CBA) method monitors the general costs and benefits of a project. Such specific method can be applied in early stages of an assessment procedure to clarify the significance of a project, evaluating and comparing the estimated costs and benefits of a number of projects. In addition, it can support decision-makers to seek for better and possible modifications and actions, providing the best return on capital. (Poveda et al. 2011).

In Cost-Benefit Analysis there are two distinguished types: the social type and economic one. The costs express in monetary terms all the potential expenditures that carried out by developer whereas the benefits refer to all potential revenues that derived from the project. CBA's functionality relies on common basis, expressed in present value terms, resulting in comparison among different projects. The existing techniques that have been developed to address the weaknesses of CBA assessment method include: community impact analysis (CIA), cost-effectiveness analysis (CEA), cost utility analysis (CUA), economic impact analysis (EIA), social return on investment (SROI) analysis, and fiscal impact analysis (FIA) (Poveda et al. 2011).

3.5 Travel Cost Theory (TCT)

Travel Cost Theory operates by predicting the economic values, which are linked to sites or ecosystems used for any recreation activity. For a specific activity that refer to the recreation of a specific area, travel cost includes benefits or costs in economic terms, which are resulted by: i) adding, ii) changing, iii) eliminating and iv) changing the environmental quality at a specific recreation area. By performing the concept of willingness to pay (WTP) for a specific good, the Travel Cost Theory measures people's willingness to pay for visiting a specific area, with reference to the total number of trips that they make at different travel costs (Poveda et al. 2011).

3.6 Community Impact Evaluation (CIE)

In 1956, Lichfield created the Community Impact Evaluation (CIE), an assessment process that was initially known as the Planning Balance Sheet (PBS). Its primary function relies on the implication of cost-benefit analysis concerning urban and local regional planning. However, CIE assessment method need also to measure the impacts regarding various sectors of a community in order to provide the outcome of the total costs and benefits of a project, communicating simultaneously the implications on social justice and equity of decisions made (Lichfield and Prat et al. 1998).

The main primary advantage of the CIE procedure include stakeholders' participation, illustrating also the role of the community, whilst its main disadvantage resulted from the data selection process that is used to monitor the social impacts (Poveda et al. 2011).

3.7 Contingent Valuation Method (CVM)

The Contingent Valuation Method (CVM) assessment process takes into consideration two main concerns: i) the environmental improvements and ii) the environmental quality reduction. Regarding the environmental improvements, the CVM includes willingness to pay (WTP), while regarding the environmental quality reduction, CVM includes willingness to accept (WTA). The CVM method uses Hicksian utility procedures to create assessments which are produced using questionnaires. In addition, CVM method relies on two critical factors, which are the hypothetical classification scenario and the development of questionnaires. However, particular scenarios or cases demand expert knowledge. Flexibility and capability to measure any non-use values are considered to be the strength points of CVM method, whilst its main weakness is the limitations for assessment whole ecosystems (Poveda et al. 2011).

3.8 Hedonic Pricing Method (HPM)

The Hedonic Pricing Method was developed by Rosen (1974), an assessment method that was based mainly on Lancaster's (1966) consumer theory. Its primary goal is to examine and present the relationship between the features and prices of particular goods. Any economic factor that has an impact on the market should be examined and assessed by Hedonic pricing method. For example, if a certain product consists of specific characteristics, each one of them associated with a specific price/value, the sum of its characteristics could provide the price of a certain property (Poveda et al. 2011).

3.9 Multi-Criteria Analysis (MCA)

Multi-Criteria Analysis (MCA) functions as an alternative assessment procedure in comparison to Cost-Benefit Analysis (CBA). The difficulty that many impacts have, which is the fact that they cannot be expressed in monetary terms, can be solved by the MCA method contribution, which evaluates and classifies the impacts in non-monetary terms. "The strength points of the MCA method include three factors: i) information present in the selected criteria, ii) weights given to each criterion and iii) agreement amongst stakeholders on the weights given to each criterion" (Poveda et al. 2011).

The MCA assessment method provide its classification taking into account the use either of decision rules or the type of handled data. "Based on the decision rule used, there are three different types of methods: compensatory, partial-compensatory and non-compensatory" (Poveda et al. 2011).

3.10 Material Intensity per Service Unit (MIPS)

In the 1990s, the Wuppertal Institute developed the Material Intensity per Service Unit (MIPS) and Ecological Rucksack assessment method. "The MIPS aggregates the overall material to calculate the total material intensity of a product or service by dividing the total material input (MI) by the number of service units (S)" (Poveda et al. 2011).

Material Intensity per Service Unit (MIPS) and Ecological Rucksack assessment method refers to the potential environmental impact that a specific production has, referring to its material and energy input flow (Spangenberg et al. 1999, Schmidt-Bleek et al. 2001). MIPS can be measured by dividing the life cycle of total material inputs, which contribute to the production, use, recycling and disposal of a product (Material Input - MI), with a specific unit of service that is chosen concerning the needs of each study. MIPS is the ideal assessment method to evaluate any product's environmental sustainability concerning its material and resource efficiency.

3.11 Analytic Network Process (ANP)

Analytic Network Process (ANP) is an assessment procedure with a network structure, which includes the Analytic Hierarchy Process (AHP). The AHP consists of specific elements including a certain hierarchy while having a target, decision criteria and alternatives. "The main components of the ANP are clusters, elements, interrelationships between clusters, and interrelationships between elements" (Brandon & Lombardi et al. 2011). According to Brandon & Lombardi (2011) there are three main stages of the process: i) the assembly of the decision-making model, ii) the development of comparisons between elements and clusters, in order to present the interactions of them within the structure model and iii) the accomplishment of the final set of priorities. The primary goal of ANP assessment process is to evaluate the elements in the structure, through comparisons, and then to rank the various alternatives. “The ANP allows interaction and feedbacks within and between clusters and provides a process to derive ration scales priorities from the elements” (Brandon & Lombardi et al. 2011).

3.12 Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) process has a primary object, which is to monitor the life-cycle of a product or service, measuring and recording its possible environmental impacts. Recognized globally also as Life-Cycle Analysis, Eco-Balance and Cradle-to-Grave Analysis, The LCA assessment method is based on ISO 14040 and BS EN ISO 14041-43. Regarding the evaluation of impacts that already existing buildings or the construction of new buildings, there are certain software tools such as BRE (Buildings Research Establishment) and BEES (Building for Environmental and Economic Sustainability). “The main interlinked components of LCA are: i) goal definition and scoping, ii) life cycle inventory, iii) life cycle impact assessment and iv) improvement analysis (interpretation)” (Poveda et al. 2011).

3.13 Sustainability/Environmental Rating Systems (SRS)

The primary object of Sustainability/Environmental Rating Systems (SRS) is to examine the environmental performance of any project, concerning the construction industry. In addition, SRS assessment procedure assist the decision-makers either throughout the life-cycle of a project or for specific stages of it. Although, there is not much interaction between designers and manufacturers, the achievement of sustainability’s purposes requires a thoroughly endeavor between all the participating groups involved. The primary benefit of such assessment method is that such an integrated approach not only supports the decision-making process but also eliminates the constructing errors. (Poveda et al. 2011).

3.14 Sustainability Reporting Guidelines (GRI)

The Global Reporting Initiative, a non-profit organization, had developed the Sustainability Reporting Guidelines (GRI) method (GRI 2011). GRI framework includes a set of reporting guidelines and principles, whose main object is to strengthen the quality and utility of sustainability reports. One important benefit of using the GRI method is that is provides a wide range of both quantitative and qualitative indicators, which can be manipulated to measure the three sustainability pillars (environmental, economic and social) in the fields of cities and industries. The measurement of environmental sustainability is accomplished through the function of seventeen primary and thirteen additional indicators (GRI 2011).

3.15 BASF method (BASF)

The BASF assessment process imply a Cradle-to-Grave analysis, evaluating the environmental effects on human well-being and ecosystems condition (Saling et al. 2002). "Environmental impacts are assessed on five key factors: i) consumption of raw materials, ii) consumption of energy, iii) emissions, iv) potential toxicity and v) potential abuse and risk" (Saling et al. 2002). Such assessment method provides various evaluation techniques, which are used to measure all the possible impacts in the fields like the discharges in surface waters, the average costs for the disposal of wastes and others. The potential outcomes can be standardized to provide the "environmental fingerprint", which can be depicted easily for public communication (Saling et al. 2002).

3.16 Quantitative Assessment of Sustainability Indices (QASI)

Quantitative Assessment of Sustainability Indices (QASI) method can be manipulated, utilizing a range of standardized impact indicators to evaluate the sustainability of alternative processes (Tugnoli et al. 2008a). The environmental pillar of sustainability can be quantifiable by quantifying of sixteen relative indicators considering fields like the emissions of air, water and land, and the resources consumption. "QASI consists of four main stages of implementation: a) selection of common reference criteria for the definition of process alternatives, b) definition of qualitative indicators, c) normalization of indicators and d) aggregation of the indicators to final sustainability indices" (Tugnoli et al. 2008a). QASI assessment method includes indicators, which manipulate the collected data at the early stages of the designing preocess (Tugnoli et al. 2008a).

3.17 Ecological Footprint (EF)

Ecological Footprint (EF) assessment procedure communicates the "theoretical area (in global hectares) required to produce the resources consumed and to assimilate wastes generated by the system under examination (i.e. society, region, person, industrial systems)" (Wackernagel and Rees et al. 1996). Estimating the EF requires "the valuation of the actual land/ water areas needed to produce resources and assimilate emissions, which are then being converted to global hectares equivalents with the application of relative factors" (Manfred et al. 2004). Furthermore, the environmental sustainability is evaluated by relating the ecological footprint with the biocapacity of a specific area.

3.18 Life Cycle Sustainability Dashboard (LCSD)

The Life Cycle Sustainability Dashboard (LCSD) method was developed, relied on the existing Dashboard of Sustainability (JRC 2013). Its main object is to provide an overview of needed guidelines in order to lead to measure and compare the sustainability of products. The operation of such method requires: i) overall view of complete life-cycle of a product and ii) proper indicators needed to be located, chosen and measured. A beneficial feature of such assessment procedure is the illustrating presentation of the potential outcomes, which is significant to increase the quality and utility of communication to public (Traverso et al. 2012a, b). In addition, LCSD can be manipulated as an ideal process to assess the three pillars (environment, social and economic) of sustainability.

4. Assessment Tools

4.1 Introduction to Assessment Tools

Sustainability's assessment tools are developed to accomplish certain sustainability targets, enhance changes regarding the already existing decisions and provide guidelines to re-design the plans for the future, assisting the decision-makers. In addition, the process of every assessment tool is similar to the one of the assessment methods, which is to monitor the progress in accomplishing specific sustainable development goals.

Until recent years, there are eight basic globally-known sustainability assessment tools (Mohammed et al. 2014):

i. Building Research Establishment Environmental Assessment Method (BREEAM) (2012).
ii. Leadership in Energy & Environmental Design (LEED) (2009).
iii. Comprehensive Assessment System for Built Environment Efficacy (CASBEE) (2007).
iv. SBTool PT- UP (2014).
v. PEARL Community (2010).
vi. GSAS / QSAS (2010).
vii. GBTool.
viii. Green Star.

Many projects, indicators, methods and tools for urban-sustainability assessment, as shown in Table 3, have emerged, highlighting the importance of the aim to guide the decision-making process to take serious steps towards sustainable urban design (Bond et al. 2012). The unique and diverse needs of cities prevent the existence of a "ready recipe" that fits all.

Therefore, many of these assessment tools have been designed for specific places. However, the adoption of indicators seems to be the most prominent way to assess urban sustainability. It is also important to consider their relevance to general policy in different countries and their ability to give a clear perception of urban elements, according to the temporal and spatial variables (Moussiopoulos, N. et al. 2010).

Table 3: Urban Sustainability Assessment tools (Mohammed et al. 2014).

Method	Examples	Country	Organization	Date	Context
Projects	- ICLEI	- Europe	- International Council for Local Environmental Initiatives	1990	Global
	- Agenda 21	- UNCED	- UN Conference on Environment and Development	1992	Global
	- SUE- Mot	- UK	- SUE- Mot O organization	2003	Global
	-Green Cities Programme	- 21 countries	- The OECD Green Cities Programme	2010	Global
Indices	- ICLEI Star Co. Index	- USA	- ICLEI Local Governments for Sustainability	2008	Global
	- Green City Index	-------	- Siemens	2009	Global
	- Eco- city Development Index	- China	- Chinese Society Building Council	2011	Local
Frameworks	- Aalborg Commitments	- Europe	- European Commission	2003	Global
	- DPSIR	- Japan	- Japan Green Build Council	2007	Local
	- BEQUEST	- USA	- US Green Building Council	2009	Local
	- Eco2 cities	- UK	- BRE/UK	2009	Local
tools	- PETUS	- Europe	- European Commission	2003	Global
	- CASBEE	- Japan	- Japan Green Build Council	2007	Local
	- LEED- ND	- USA	- US Green Building Council	2009	Local
	- BREEAM Community	- UK	- BRE/UK	2009	Local

4.2 Building Research Establishment Environmental Assessment Method (BREEAM)

In 1990, in the United Kingdom, the BREEAM assessment tool was developed to evaluate sustainability. In the beginning, it was concerned to be manipulated as environmental assessment tool generally for the construction sector and especially for buildings (BREEAM Communities 2013). Afterwards, in 2009, this assessment tool was renamed as BREEAM Community, which is the latest version of the BREEAM family, focusing on the evaluation of sustainable factors of urban areas while expanding its goals regarding the sustainable urban design from its very early phases (Mohammed et al. 2014).

The Building Research Establishment Environmental Assessment Method (BREEAM) includes various environmental issues, which are classified in three main issues areas (Poveda et al. 2011):

i. “Global issues, which includes CO_2 emissions, acid rain, ozone depletion, natural resources and recyclable materials, storage of recyclable materials, and designing for longevity” (Poveda et al. 2011).

ii. “Local issues, which include transport and cycling facilities, noise, local wind effects, water economy, overshadowing or other buildings and land, reuse of derelict/contaminated land, and the ecological value of the site” (Poveda et al. 2011).
iii. “Indoor issues, which involve hazardous materials, natural and artificial lighting, thermal comfort, and overheating and ventilation” (Poveda et al. 2011).

Every separate issue is characterized by a specific credit, which is given if only its design accomplishes the requirements towards that particular issue. The aggregation of the overall credits expresses the overall performance in a scale of importance, which depends on a specific minimum level of credits of the three main areas of issues (e.g. global, local and indoor issues). BREEAM assessment tool consists of nine different categories, each with a pre-defined environmental evaluation (Poveda et al. 2011). For example, the nine categories are the following:

“Management (12%) Health & Wellbeing (15%) Energy (19%),

Transport (8%) Water (6%) Materials (12.5%),

Waste (7.5%) Land Use & Ecology (10%) and Pollution (10%)” (Poveda et al. 2011).

4.3 Leadership in Energy & Environmental Design (LEED)

In 1993, the rapid growth of recognition of the characteristics that the sustainability presented, particularly in the construction industry field, resulted in the development of the USGBC tool (United State Green Building Council) as the first attempt of LEED assessment tool. The Leadership in Energy and Environment Design process constitutes an assessment tool especially for green buildings. In 2007, the first experimental version was launched, whose evolution into the current ratings system in 2009-2010 includes also the neighborhood development (ND), which is the main element of urban design for cities (LEED 2011).

The National Institute of Standards and Technology (NIST) determines and weights directly the essential impact categories, by using the impact categories that are provided by the US Environmental Protection Agency’s TRACI project (Bare et al. 2002).

Activity groups refer to the main building functions. LEED provides credits go towards one of those activity groups. Activity groups are related with particular building impacts in each category. Such categories are described as follows (Poveda et al. 2011):

- “Building systems (specifically fuel and electricity consumption).
- Transportation (commuting and services).
- Water consumption (domestic and landscaping-related).
- Materials (core, shell, and finishing).
- Indoor Environmental Quality” (Poveda et al. 2011).

4.4 Comprehensive Assessment System for Built Environment Efficacy (CASBEE)

In 2007, the Comprehensive Assessment System for Built Environment Efficacy (CASBEE) assessment tool was developed by the Japan Green Building Council and the Japan Sustainable Building Consortium, operating for the first time in 2002 especially for office buildings. CASABEE’s functionality can be applied in a wide range of sustainability assessment cases in fields like new or already existing buildings, renovation projects, urban development, etc. However, its main target is to assess only the sustainability of exterior areas of buildings, without taking into consideration what is happening inside the buildings (JSBC and JaGBC et al. 2007).

The environmental efficiency and the impact on the environment are the two main factors, which characterize the quality of the exterior area of the buildings. The CASBEE assessment tool handles two factors: the Quality Q and the Loadings L. The Quality (Q) refers to Building Environmental Quality and Performance, evaluating the progress on living conditions. Quality Q consists of: i) the interior environment, ii) the quality of offered services and iii) the exterior environment. Loadings (L) refer to Building Environmental Loadings, measuring the negative factors of environmental impacts (CASBEE 2006). Loadings (L) consist of data regarding energy, resources, and the exterior environment. CASBEE can create sufficient outcomes, counting the BEE (building environmental efficiency), with the equation BEE = Q / L (Poveda et al. 2011).

4.5 SBTool

In 1996, the GBTool was invented and firstly launched by iiSBE (International Initiative for a Sustainable Built Environment), assessing sustainability in the fields of buildings and particular green buildings, established. In 2005, this assessment tool was re-named to SBTool (Larsson et al. 2012). According to Larson (2012), SBTool's main object is to develop local-design and construction methods before its first public use. In addition, one particular indicator, called SBTool PT, focuses on building-sustainability assessment in Portugal. The SBTool PT - UP (The Portuguese sustainability assessment method) refers to sustainability assessment for urban planning and designing. (Mohammed et al. 2014).

4.6 The Pearl Community rating system for Estidama - UAE

To begin with, sustainability, in the Arabic language, is called "Estidama". In 2010, the Pearl Community rating system was developed and launched by the Abu Dhabi Urban Planning Council and its first introduction was linked with the Plan Abu Dhabi 2030. Such attempt was the first in the Middle East, trying to fulfill the need of establishing buildings standards and sustainable urban planning and design, in the United Arab Emirates. Pearl assessment tool is focused on the stockholders expressing also the processes of planning, designing and construction. Also, it combined a cultural dimension, as a fourth dimension of sustainability apart from economy, environment, and society, offering privacy and spatial impact to the assessment process (Estidama et al. 2010).

Elgendy (2014) mentioned that the Pearl Community rating system have been developed on the basis and following the principles of BREEAM and LEED assessment tools, attempting to acknowledge the weaknesses and differences between the two methods and to work on the development of a rating system consistent with the spatial and cultural dimensions of the UAE. Estidama Pearl Rating System is a specific document for three different standards varying in rating size, offering a guide for assessing the sustainability concerning the fields of construction and communities. Therefore, The Pearl Community rating system operated as an ideal standard for urban planning and designing, concerning projects in UAE (Mohammed et al. 2014).

4.7 Qatar Sustainability Assessment System (GASA/QASA)

In 2009, the Qatar Sustainability Assessment System was developed by Gulf Organization for Research & Development (GORD) in collaboration with the Centre for Energy Studies and Building Simulation at the University of Pennsylvania (U.S.A). Afterwards, it was changed to GSAS (Global Sustainability Assessment System) (QSAS 2010). The rapid growth and expansion of the construction industry in the Gulf region, resulted in necessity of developing an assessment and ranking system regarding sustainability of urban development and buildings to reduce multiple-negative environmental impacts, meeting also the local needs and culture of Qatar. GSAS adopted wide integrated practices and global assessment of the sustainability of buildings and the urban environment, taking into consideration local environmental and spatial characteristics (Mohammed et al. 2014).

4.8 GBTool

The GBTool assessment process has its fundamental operation principles based on LEED and BREEAM assessment tools, including also the life-cycle methodology accompanied with an assessment classification scale. The scores are assigned in a range of -2 to +5, described as follows (Poveda et al. 2011):

- "-2 and -1: the level of performance is below acceptance levels in the specific region.
- 0: the minimum level of acceptable performance in the specific region.
- 3: best practice.
- 5: best technically achievable, without cost consideration" (Poveda et al. 2011).

The above mentioned ranking scores refer to the four separate stages concerning any building activity, which consists of the pre-design, the design, the construction and the operations stages, while each separate stage contains certain issues, categories, criteria and sub-criteria (Poveda et al. 2011).

4.9 Green Star

The Green Star assessment tool includes "nine categories: i) management, ii) indoor environment quality, iii) energy, iv) transport, v) water, vi) materials, vii) land use &

ecology, viii) emissions and ix) innovation. Those nine categories are used to assess the environmental impact that is directly linked to selection of project site, design, construction, and maintenance” (Poveda et al. 2011). Each category operates by examining and evaluating the new action plans for development or the designing plan for the improvement of environmental performance. Alike with the LEED and BREEAM assessment processes, whose each category is characterized by certain weighting points, the Green Star evaluates its nine categories by taking into consideration scientific and stakeholder involvement, which includes: “i) the OECD Sustainable Building Project Report, ii) the Australian Greenhouse Office, iii) Environmental Australia, iv) CSIRO, v) the Cooperative Research Center for Construction, vi) the Commonwealth Department of Environment and Heritage, and vii) a national survey conducted by the Green Building Council” (Poveda et al. 2011).

“The weighting credits vary by geographical location. The weighted category score is calculated using the following formula:

Weighted Category Score = Category Score (%) x Weighting Factor (%) / 100” (Poveda et al. 2011).

4.10 Comparison of Urban Sustainability Assessment Tools

The sustainability assessment tools differ in terms of functionality, limitations, assessing procedure and weighting credits, and their applicability, although they have been developed to serve the same purpose (Gil and Duarte et al. 2013, Khandokar et al. 2009). However, the primary similarity of all the previously mentioned assessment tools depends on their organizational structure, borders, working methods and their corresponding outcomes to accomplish an unbiased comparison on the basis of their common foundations (Mohammed et al. 2014).

As noted above in the previous separate chapters, the majority environmental/sustainable rating systems use same methods that contribute to their credit weighting tools, except for CASBEE. However, the majority of rating systems relies on the Life-Cycle Analysis procedure, having similarities to Environmental Management Systems (EMS) (Papadopoulos and Giama et al. 2009). The main target of EMS is the constant improvement of the environmental quality. Thus, In order to select the most suitable assessment tool there are specific standards and principles, which should be met and fulfilled such as: “measurability, applicability, availability, development, usability, system maturity, technical content, communicability and cost” (Poveda et al. 2011).

The indicators distribution of the assessment tools include mandatory determinants, and despite the similarities of some of the indicators, the assessment tools have been designed on the basis of priorities and local conditions of the origin of each country, regarding the observance of climatic conditions, social dimensions, environmental problems and economic conditions as well as local cultural issues. All those six globally known tools have one primary goal, but with many forms and different focus on the importance of urban indicators. These tools show a wide coverage of issues but still with missing elements such as technology and cultural issues, in local region and the relationship with sustainability (Mohammed et al. 2014).

Nevertheless, indicators of assessment tools come with a great importance, supporting the decision-making process of the urban sustainability projects. Their contribution starts from the designing of each concept until the completion of the project (Wedding and Crawford-Brown et al. 2007). Furthermore, the importance of the indicators of sustainable urban design refers to their characteristics. Such indicators are relevant, scientifically proper, clear, achievable, practical and measurable in order to display the priorities, objectives and local operations of the urban environment. The main dimensions of sustainability - economy, environment and society - represent the foundation and line initiation to determine the indicators for each tool (Moussiopoulos et al. 2010).

The three pillars of sustainability (environment, society and the economy) allow widely the overlapping in concepts and also the multi-interpretations of indicators. Therefore, the wide variety of urban indicators contributes to solve the overlap by giving the privacy of indicators, in addition to determining its special values of the weighting percentages. In general, many researchers agree that the reductive in the number of indicators and inadequate constitutes stands as a negative factor to achieve performing of sustainability in urban design (Shen et al. 2011). As a result, urban sustainability indicators should be detailed and flexible, being capable to promote the concepts of sustainability. The following figure (Figure 3) illustrates the disparity in coverage of the sustainability assessment tools.

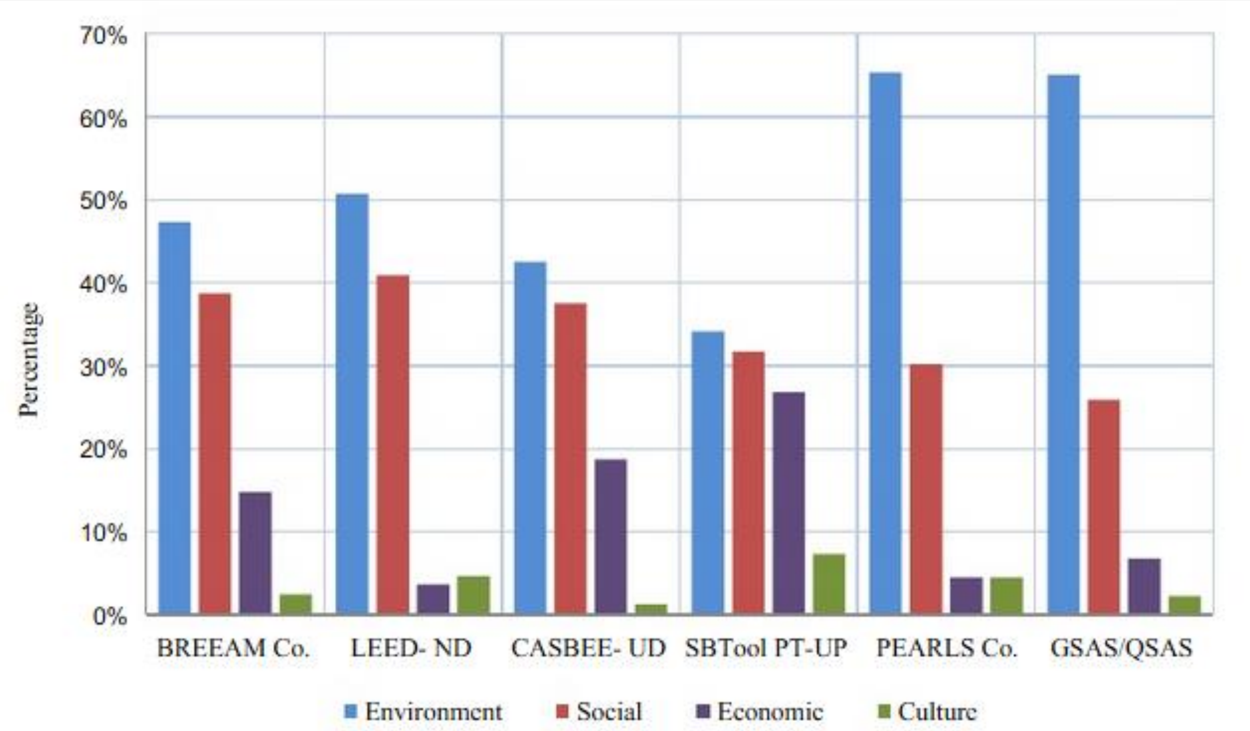

Figure 3: The disparity in coverage of the sustainability assessment tools (Mohammed et al. 2014).

5. Assessment Indicators

5.1 Introduction to Assessment Indicators

The primary object of any urban sustainability assessment process is to monitor and evaluate the quality of urban systems and the potential impacts that cities exert on their surrounding environment, both at local and global scale. The interactions between urban systems and the environment can be defined by indicators, regarding the fields of resources, human well-being and ecological support systems.

“Sustainable indicators (SI) are an essential and powerful tool in decision-making for sustainability and of any sustainable assessment (SA)” (Dahl et al. 2012, Pinter et al. 2012). Agenda 21, for example states that SI “[…] need to be developed to provide solid bases for decision-making […]” (UN Earth Summit - AGENDA 21, 2014).

“A useful set of indicators should be able to describe both i) whether urban quality and performance in cities is improving or deteriorating in relation to certain sustainability criteria or desirable targets and ii) how these trends in urban quality and performance are linked to trends in spatial structures, urban organization and lifesytles” (Alberti et al. 1996).

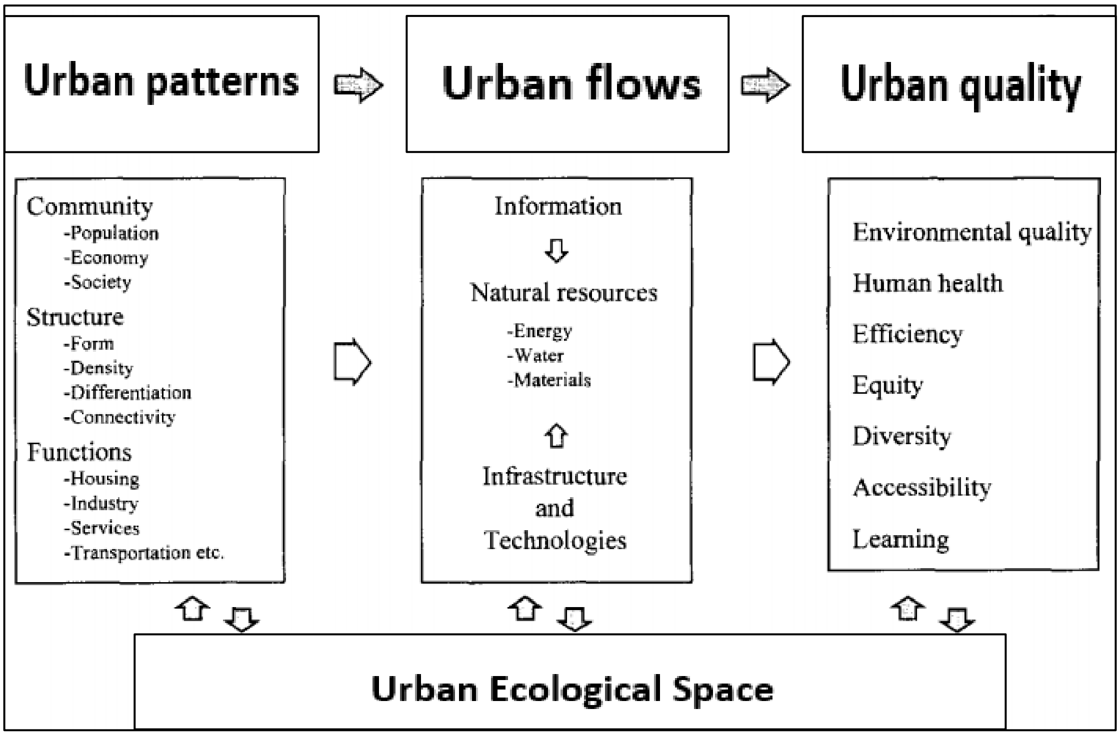

Figure 4: Urban sustainability indicators (Alberti et al. 1996).

For each of these dimensions, indicators can be specified as symptoms or casual factors affecting sustainability. The major categories of indicators are summarized in the previous Figure 4.

5.2 Object of Sustainability Assessment Indicators

Urban sustainable indicators play an important role to help local and national policy-makers improve their action towards sustainability. "They serve several purposes:

- systematic monitoring of urban environmental changes,
- early warning of urban environmental problems,
- target setting,
- performance reviews and
- public information and communication" (Alberti et al. 1996).

Sustainability indicators' main objects support the decision-making process regarding designing the strategy for sustainable development while their contribution have positive effects on sustainability decision-making challenges.

In general, "sustainability assessment indicators contribute to:

- Structure complexity and communicate information (information-structuring challenge).
- Operationalization of sustainable development (interpretation challenge).
- Social learning (interpretation and influence challenge).
- Demonstrate accountability and benchmarking (influence challenge).
- Identification of knowledge and data gaps (information-structuring challenge)" (Waas et al. 2014)

Firstly, sustainable indicators provide essential information to decision-makers regarding sustainable development progress (Dahl et al. 2012, Moldan et al. 2007, Hezri et al. 2004). Demonstrating such information, sustainable indicators clarify the need of a specific system for sustainability, while make it even more tangible by measuring, collecting and presenting certain data. In addition, operating sustainability assessment indicators enhance the transparency of changes and transformations that can be monitored and communicated to public.

Secondly, sustainability indicators perform sustainable development (Bell et al. 2005, Malkina et al. 2002), providing clear discussions with tangible data and information to design policy makers, in contrast with abstract theoretical formulations. In addition, "sustainability indicators strengthens the discussions on concepts with operational meaning (Rigby et al. 2001), which is a requirement for the practical implementation of sustainability" (Rennings et al. 1997).

Thirdly, "sustainability indicators contributes to continuous learning among involved stakeholders" (Meadows et al. 1998) and "their evolution accompanied with their application could be considered as a way of social learning" (Bell et al. 2004). Effectiveness of sustainability indicators can be evaluated whether they assist and promote social learning or not (Shields 2002). Furthermore, sustainability indicators could modify sufficiently the point of view of decision-makers and the decision-making process (Meadows et al. 1998).

Fourthly, "sustainability assessment indicators demonstrate accountability to society and its stakeholders, communicating systems sustainability performance, for example corporate social responsibility/accountability of businesses" (Bebbington et al. 2007).

Finally, sustainable indicators contribute to clarify the differences among stakeholders while also monitor the existing knowledge and suggest actions to capture data gaps (Hodge et al. 1999).

5.3 Urban Sustainability Indicators (USI)

The Urban Sustainability Indicators (USI) assessment method operates by clarifying and providing the essential information in order to improve the quality of communication among scientists, policy design-makers and the public. By clarifying a all the essential information, urban sustainability indicators could lead to important conclusions by making linkages between simple and complex sustainability issues, concerning the three pillars of sustainability. In addition, sustainability indicators could measure trends regarding sustainability matters, supporting policymakers and the public to measure sustainability performance over time (WRI 1995).

Various urban assessment indicators have been developed by six international organizations (Alberti et al. 1996), which are:

- UNCHS and the World Bank.
- UN/UNCSD.
- OECD.
- EEA.
- WHO.

5.3.1 The UNCHS & the World Bank indicator

The UNCHS and the World Bank have created indicators, which resulted in covering a wide range of key issues. Such key developed indicators cover and demonstrate a group of principles for seven sectors concerning the objectives of stakeholders' viewpoint. As a result, such indicators contribute to measure the designed policies to meet these objectives. "The classification of indicators refer to seven categories: 1) socioeconomic development, 2) infrastructure, 3) transport, 4) environmental management, 5) local government, 6) affordable and adequate housing, and 7) housing provision" (Alberti et al. 1996). In addition, the UNCHS indicator assessment method provides also demographic indicators (Alberti et al. 1996).

5.3.2 The UN/UNCD indicator

The UN Commission on Sustainable Development (1996) attempts to develop sustainability indicators in order to monitor the development course of sustainability, at an urban scale. Respectively, UNCSD indicators function mainly at a national scale (Alberti et al. 1996).

5.3.3 The OECD indicator

In recent years, OECD organization acknowledges the innovative outcomes of the urban indicators and as a result it supports policymakers to monitor urban design-making policies. Such developed indicators operate as a group of environmental indicators to assess the environmental performance. Simultaneously, a general indicator framework, the Pressure-State Response (PSR) appraisal, has been developed by OECD in order to support the integration of environmental concerns into the decision-making process at a national scale (Alberti et al. 1996).

5.3.4 The EEA indicator

In 1995, the European Environment Agency (EEA) has developed its sustainability indicator framework to contribute on reporting the quality of Europe's environmental performance. The core of the EEA indicator framework consists of the following factors: i) the environmental problems, ii) the reasons of the environmental pressure and iii) the human activities, responsible for them. Needed actions can be taken during the assessment process to clean up, control, or prevent environmental problems to happen (Alberti et al. 1996).

5.3.5 The WHO indicator

The World Health Organization (WHO) has developed specific urban health indicators as part of its Healthy City Project, which began in 1986 to test and improve WHO strategy defined as Health for All (HFA) at the local level. According to HFA, there are five principles, which guide health policies: 1) equity, 2) empowerment, 3) participation, 4) cooperation and 5) local primary health care (Alberti et al. 1996).

5.3.6 Comparison of Urban Sustainability Assessment Indicators

The previously mentioned groups of urban sustainability indicators illustrate how the different organizations evaluate the various factors of sustainability. First of all, the OECD and the UNCSD organizations provide their developed groups of indicators, attempting to evaluate the environmental performance at a national level. However, the OECD's group of (environmental) indicators mostly measure environmental performance while the UNCSD's group of indicators measure sustainable development (Alberti et al. 1996).

In addition, the UNCSD's indicators framework attempts to expand its group of indicators consisting of social, economic, environmental and institutional indicators. Similarly, the UNCHS, the EEA and WHO organizations have developed groups of indicators in order to evaluate social, economic and environmental factors of sustainability, at an urban scale. However, the UNCHS's group of indicators focuses on the socioeconomic factors of urban sustainability while the EEA's and WHO's group of indicators focuses mainly on the environmental and human well-being factors of urban sustainability (Alberti et al. 1996).

“Most urban indicator programs refer to four key characteristics of successful indicators:

- Policy relevance.
- Scientifically founded.
- Readily implemented.
- Usable for decision-making” (Alberti et al. 1996).

5.4 European Common Indicators (ECI)

In 1999, the European Environment Agency (EEA) developed the European Common Indicators (ECI), an assessment process that operates by supporting the local sustainability assessment and by monitoring the urban environmental performance and quality. In addition, the European Common Indicators can operate accompanies with other assessment indicators, methods and tools, resulting in achieving comprehensive local examining sustainability design-making strategy (ECI 2003).

Since its first launch, the primary object of the ECI assessment process is to develop the suitable indicators processes to examine and present local actions towards sustainability. The developed group of indicators remains constantly flexible to various relevant topics (ECI 2003). However, at the early stages of the assessment, the group of indicators referred to a limited range of factors, improving and implementing effectively some fundamental methodologies.

Further, ECI operates with respect to existing local, regional and national and group of indicators. In fact, the ECI goal is to communicate various local actions concerning sustainability, in as much effective and sufficient integrated way (ECI 2003).

“The 2001-2002 phase included the following main activities:

1. Technical support and methodological development,
2. Pilot activities on Ecological Footprint,
3. Promotional/dissemination actions and signatories increasing,

4. Data collection and data analysis.

5. Evaluation of the ECI initiative based on interviews and on a survey on actual and potential users (and on analysis of ECI implementation good practices).

6. Development of conclusions and recommendation” (ECI 2003).

The result of various and extensive evaluating experiments with local and regional areas resulted in the establishment of a list of 10 common issues/indicators. The ten European Common Indicators were defined using a bottom-up procedure.

The European Common Indicators

1. Citizens' satisfaction with the local community
   Headline indicator: Average satisfaction with the local community (overall and mean)
2. Local contribution to global climate change
   Headline indicator: CO_2 emission per capita
3. Local mobility and passenger transportation
   Headline indicator: Percentage of trips by motorized private transport
4. Availability of local public open areas and services
   Headline indicator: Percentage of citizens living within 300 metres from public open areas >5000 m^2
5. Quality of the air
   Headline indicator: Number of PM_{10} net overcomings
6. Children's journeys to and from school
   Headline indicator: Percentage of children going to school by car
7. Sustainable management of the local authority and local enterprises
   Headline indicator: Percentage of environmental certifications on total enterprises
8. Noise pollution
   Headline indicator: Percentage of population exposed to L_{night} >55 dB(A)
9. Sustainable land use
   Headline indicator: Percentage of protected area
10. Products promoting sustainability
    Headline indicator: Percentage of people buying sustainable products

Figure 5: The 10 European Common Indicators (ECI 2003).

In addition, several other projects have applied the ECI set (ECI 2003):

- The Adriatic Action Plan 2020 project, as a model for the definition of the Adriatic Common Indicators (ACI).
- The definition of Nordic Larger Cities Environmental Indicators.

- The Catalan Network of Cities and Towns towards Sustainability, as a model to define the Municipal System of Sustainability Indicator (ECI 2003).

5.5 Towards Environmental Pressure Indicators for the EU (EU TEPI)

Environmental Pressure Indicators assessment procedure's function is based on the attempts to communicate to public and decision-makers all the essential information, undertaken by the Commission, aiming to monitor and re-design an efficient environment policy for the European Union. This assessment procedure contains a group of indicators, such as local or regional indicators and sustainable development indicators, which is accompanied by a relevant indicators framework. Such indicators framework was developed by the "Communication from the Commission to the Council and the European Parliament on Directions for the EU on Environmental Indicators and Green National Accounts" (EU TEPI 2001).

In 1999, the first edition of the TEPI EU, which was developed by the Eurostat, contains about 48 indicators, of which the 22 indicators are created by Eurostat, while the others are based on Eurostat's data that is derived from other sources, variables and methodologies (EU TEPI 2001).

In 2001, the "Environment 2010: Our future, Our choice" was published by The Communication of the Commission on a Sixth Environment Action Program, demonstrating all the essential and existing knowledge of current environmental problems. The following figure (Figure 6), presents the nine different indicators policy fields of the publication, which are the following (EU TEPI 2001):

- "Resource Depletion.
- Waste.
- Dispersion of Toxic Substances and Water Pollution.
- Marine Environment & Coastal Zones.
- Climate Change and Air Pollution.
- Ozone Layer Depletion.
- Urban Environmental Problems" (EU TEPI 2001).

Policy field							
Resource Depletion	**Water consumption**	**Use of energy**	**Increase in territory permanently occupied by urbanisation; infrastructure...**	**Inputs of phosphate to agricultural land** (changed from Nutrient balance of the soil)	**Electricity production from fossil fuels**	**Timber balance**	
Waste	**Waste landfilled**	**Waste incinerated**	**Hazardous waste**	**Municipal waste**	**Industrial waste** (replacing Waste per product during a n° of products entire lifetime)	**Waste recycled/material recovered**	
Dispersion of Toxic Substances	**Consumption of pesticides by agriculture**	**Emissions of persistent organic pollutants (POPs)**	**Consumption of toxic chemicals**	**Index of heavy metal emissions to water**	**Index of heavy metal emissions to air**	***No indicator*** (formerly Emissions of radioactive material)	
Water Pollution	**Emissions of nutrients by households** (changed from Nutrient use)	**Emissions of nutrients by industry** (changed from Ground water abstraction)	**Pesticides used per hectare of utilised agriculture area**	**Nitrogen used per hectare of utilised agriculture area**	**Emissions of organic matter by households** (replacing Water treated/water collected)	**Emissions of organic matter by industry** (changed from Emissions of organic matter as BOD)	
Marine Environment & Coastal Zones	**Eutrophication**	**Fishing pressure**	**Development along shore**	**Wetland loss in coastal zones** (previously LB-2 Wetland loss)	**Discharges of heavy metals**	**Oil pollution at coast & at sea**	**Tourism intensity** (replacing Discharges of halogenated organic compounds
Climate Change	**Emissions of carbon dioxide (CO_2)**	**Emissions of methane (CH_4)**	**Emissions of nitrous oxide (N_2O)**	**Emissions of HFCs, PFCs and SF_6** (replacing Emissions of CFCs)	***No indicator*** (formerly Emissions of NO_x)	***No indicator*** (formerly Emissions of SO_x)	
Air Pollution	**Emissions of nitrogen oxides (NO_x)**	**Emissions of volatile organic compounds (VOCs)**	**Emissions of sulphur dioxide (SO_2)**	**Emissions of particles**	**Consumption of gasoline & diesel oil by road vehicles**	**Primary energy consumption**	
Ozone Layer Depletion	**Emissions of bromofluoro-carbons (halons)**	**Emissions of chlorofluoro-carbons (CFCs)**	**Emissions of hydrochloro-fluorocarbons (HCFCs)**	**Emissions of chlorinated carbons** (formerly OD-5)	**Emissions of industrially produced CH_3Br** (formerly OD-6)	***No indicator*** (former OD-4 Emissions of NO_x by aircraft deleted)	
Urban Environmental Problems	**Urban energy consumption** (changed from Energy consumption)	**Non-recycled municipal waste**	**Non-treated urban wastewater** (changed from Non-treated wastewater)	***No indicator*** (formerly Share of private car transport)	***No indicator*** (formerly People endangered by noise emissions)	***No indicator*** (formerly Urban land-use)	

Figure 6: The nine different indicators policy fields of the Environmental Pressure Indicators for the EU (EU TEPI 2001).

5.6 Cities Environment Reports on the Internet (CEROI)

The Agenda 21 requires that all the related groups of stakeholders, such as politicians, citizens, design-policy makers etc., should be provided with easily accessible environmental information, in order for a local environment to be characterized as sustainable. Therefore, in 1992, the UNCED Earth Summit Conference endorsed the CEROI Program towards the improvement of public access to all the necessary environmental information. The CEROI Program consists of a template with a set of core indicators accompanied by customized specific software in order to produce the urban environmental report and to simplify the demonstration of the respective outcomes like maps, graphs, text and images, on the Internet (Fjøtoft et al. 2002).

"The CEROI Program operates mainly as a tool that provides access to urban environmental information, raising public knowledge and increasing the mediation and participation necessary to ensure sustainable and environmentally sound development" (Fjøtoft et al. 2002). Its primary object is to provide a network platform, where cities worldwide can make available and easily accessible information regarding their environmental performance. The specific network provides information in an easy-to-understand way, well organized with comparable format among cities globally. The implementation of the CEROI network contributes to a well-organized way of communication of cities' environmental management and performance, making it also easily for global comparisons among cities worldwide (Fjøtoft et al. 2002).

5.7 Environmental Performance Index (EPI)

The Environmental Performance Index (EPI) was initially presented by the Universities of Yale and Columbia. The EPI index includes countries and uses indicators oriented towards results, so that it serves as an index of comparison, thus permitting better understanding on the part of politicians, scientists, environmental defenders and the general public.

Categories of environmental policy reflected by the EPI	
1. Environmental Health 2. Water (effects on human health) 3. Air pollution (effects on human health)	4. Air pollution (effects on the ecosystem) 5. Water Resources (effects on the ecosystem) 6. Biodiversity and Habitat 7. Forests 8. Fishing 9. Agriculture 10. Climate Change and Energy

Categories of environmental policy reflected by the EPI	
11. Environmental Health 12. Water (effects on human health) 13. Air pollution (effects on human health)	14. Air pollution (effects on the ecosystem) 15. Water Resources (effects on the ecosystem) 16. Biodiversity and Habitat 17. Forests 18. Fishing 19. Agriculture 20. Climate Change and Energy

Figure 7: The 20 performance indicators reflected by the Environmental Performance Index (EPI 2013).

The Environmental Performance Index (EPI) classifies every county's performance on certain environmental issues regarding the protection of two main categories: i) human health and ii) ecosystems.

"The EPI is based on two main objectives of the environmental policy:

1. Environmental Health, which measures environmental pressures on human health.
2. Ecosystem Vitality, which measures the health of ecosystems and the management of natural resources" (EPI 2013).

The EPI evaluates the countries using 20 performance indicators, which cover nine issue categories, illustrating specific indicators for both environmental health and ecosystem vitality. These environmental issue categories are presented in the following figures (Figure 8 and 9).

EPI	Objective	Issue Category	Indicator
Environmental Performance Index (EPI)	Environmental Health (50%)	Health Impacts (33%)	Environmental Risk Exposure (100%)
		Air Quality (33%)	Household Air Quality (30%)
			Air Pollution - Average Exposure to PM2.5 (30%)
			Air Pollution - PM2.5 Exceedance (30%)
			Air Pollution - Average Exposure to NO2 (10%)
		Water and Sanitation (33%)	Unsafe Sanitation (50%)
			Drinking Water Quality (50%)
	Ecosystem Vitality (50%)	Water Resources (25%)	Wastewater Treatment (100%)
		Agriculture (10%)	Nitrogen Use Efficiency (75%)
			Nitrogen Balance (25%)
		Forests (10%)	Change in Forest Cover (100%)
		Fisheries (5%)	Fish Stocks (100%)
		Biodiversity and Habitat (25%)	Terrestrial Protected Areas (National Biome Weights) (20%)
			Terrestrial Protected Areas (Global Biome Weights) (20%)
			Marine Protected Areas (20%)
			Species Protection (National) (20%)
			Species Protection (Global) (20%)
		Climate and Energy (25%)	Trend in Carbon Intensity (75%)
			Trend in CO2 Emissions per KWH (25%)

Figure 8: General framework of the Environmental Performance Index 2016 (https://en.wikipedia.org/wiki/Environmental_Performance_Index).

Figure 9: The 2016 EPI Framework includes 9 issues and more than 20 indicator (Hsu et al. 2016).

5.8 Environmental Sustainability Index (ESI)

The Yale University and the Columbia University, in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission have developed the Environmental Sustainability Index (ESI).

The Environmental Sustainability Index (ESI) assessment procedure is the ideal tool for the nations to communicate their actions and plans to protect the environment over the coming years. Between 1999 and 2005, the ESI was firstly launched and since then operates as an assessment procedure that is developed to: i) support environmental policy-makers, ii) define the process of the environmental design-policy, iii) demonstrate environmental performance and iv) facilitate efforts to find best practices (ESI 2005).

Although, its primary function is to operate as a sustainability assessment process, the ESI procedure is commonly used to support policymakers to observe the various trends in a wide range of environmental sectors such as the environmental pollution, the use of natural resources, the environmental quality as well as social and economic factors and as a result it can capture efficiently and transparently the three pillars of sustainability.

In addition, the ESI Score procedure measures and provides the respective ranking positions of countries worldwide concerning their environmental performance. However, much more analyzed information derives through the 21 indicators (ESI 2005). The construction of the ESI Score is presented in the following figure (Figure 10).

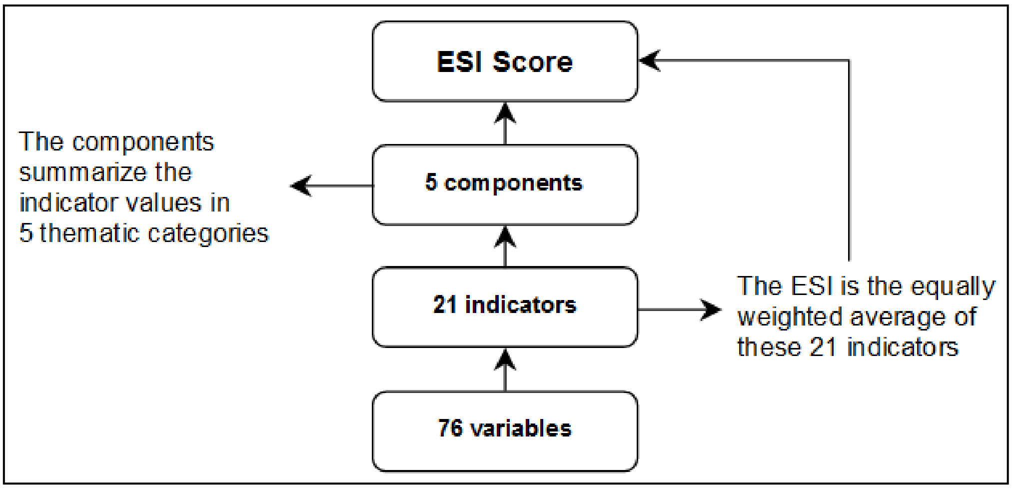

Figure 10: Construction of the ESI Score (ESI 2005).

The construction score of ESI operates by integrating 76 variables regarding environmental issues into 21 indicators of environmental sustainability. The used environmental policy model, called the “Pressure-State-Response”, which manipulates the relevant indicators and variables in order to produce the respective outcomes.

These indicators contribute to present sufficient comparison towards issues of the following five categories (ESI 2005):

- “Environmental Systems.
- Reduce of Environmental Stresses.
- Reduce of Human Vulnerability to Environmental Stresses.
- Societal and Institutional Capacity to Respond to Environmental Challenges.
- Global Stewardship” (ESI 2005).

Regarding the environmental systems, the ESI assessment procedure covers natural and managed systems, including also measurements of the reduction of natural resources and pollution levels. In addition, the ESI evaluates human exposure to environmental changes and the level of impacts that such changes have (ESI 2005). Finally, the ESI illustrates the way each society deals with environmental stresses and how every country corresponds to global stewardship. Those five basic categories (components) and their logic are presented in the following figure (Figure 11) (ESI 2005).

Component	Logic
Environmental Systems	A country is more likely to be environmentally sustainable to the extent that its vital environmental systems are maintained at healthy levels, and to the extent to which levels are improving rather than deteriorating.
Reducing Environmental Stresses	A country is more likely to be environmentally sustainable if the levels of anthropogenic stress are low enough to engender no demonstrable harm to its environmental systems.
Reducing Human Vulnerability	A country is more likely to be environmentally sustainable to the extent that people and social systems are not vulnerable to environmental disturbances that affect basic human wellbeing; becoming less vulnerable is a sign that a society is on a track to greater sustainability.
Social and Institutional Capacity	A country is more likely to be environmentally sustainable to the extent that it has in place institutions and underlying social patterns of skills, attitudes, and networks that foster effective responses to environmental challenges.
Global Stewardship	A country is more likely to be environmentally sustainable if it cooperates with other countries to manage common environmental problems, and if it reduces negative transboundary environmental impacts on other countries to levels that cause no serious harm.

Figure 11: Environmental Sustainability Index Building Blocks – Components (ESI 2005).

5.9 MNP European Benchmark Indicators

The MNP has developed the European Benchmark Indicators (EBI) to communicate and make easily accessible comparisons between the quality of Member States environmental performance. The first version of the EBI assessment process was published in 2006, completing one year of experiments regarding indicators, models, indicators and relevant outcomes.

Consisting of various indicators in its environmental performance database, the ESI procedure operates providing outcomes and comparisons among Member States. Data sources are include among other organizations: Eurostat, World Bank, the European Environment Agency (EEA) and the World Resources Institute (Vixseboxse et al. 2007).

The Netherlands Environmental Assessment Agency (MNP) has put together a set of existing benchmark indicators (see Appendix, Figure I) so that a country's environmental performance can be placed in a European perspective. The EBI indicators are divided into two categories. The first category consists of socioeconomic profile indicators and the second category consists of environmental profile.

The first category, the socioeconomic profile, includes certain attributes of a country, providing information regarding the economic performance, its structure and its social attributes that every Member State has. In cases where it is possible, the relevant indicators could provide specific data to illustrate the progress, covering elements from the past, present and a possible vision of the future (Vixseboxse et al. 2007).

The second category, the environmental profile, consists of the OECD Pressure-State Responses (PSR) framework. Depending on the two main subjects of the Air Quality and Climate Change, the environmental profile is divided into separate sectors, including elements regarding environmental pressures, clean available technology, environmental quality and policy, and potential progress towards International Commitments (Vixseboxse et al. 2007).

5.10 Indicators of Sustainable Production (ISP)

Indicators of Sustainable Production (ISP) (Veleva and Ellenbecker et al. 2001) have been developed to support and measure the progress that production systems have, regarding their sustainable development. The ISP assessment method operates, according to an eight stages procedure. The ISP assessment method is devided inot two groups of basic and additional indicators. The twenty two basic indicators are used for assessing various sustainability issues regarding different production systems. "The eleven additional indicators contribute to measure the environmental sustainability, being categorized into three main groups: i) use of energy and material, ii) environment and iii) products" (Veleva and Ellenbecker et al. 2001).

5.11 Wuppertal Sustainability Indicators (WSI)

Wuppertal Sustainability Indicators (WSI) method consists of sustainability assessment indicators, which can be integrated at different stages of the assessment process. The WSI procedure provides information regarding the interactions that occur among the three pillars of sustainability (environmental, economic and social indicators). “Examples of the indicators included in this method are: i) resource intensity, ii) transport intensity, iii) resource productivity and others” (Spangenberg and Bonniot et al. 1998). The WSI method was created to identify the expected future problems and not to provide solutions concerning impacts or damages (Spangenberg and Bonniot et al. 1998).

5.12 Organizational Sustainability Performance Index (OSPI)

Following the principles of the existing Classic Balanced Scorecard, the Organizational Sustainability Performance Index (OSPI) assessment method relies its functionality on the development of a sustainable balanced scorecard (SBSC), combining both the social and the environmental matters. The development of the SBSC includes six assessment categories, referring to environmental sustainability while assisting also various industry matters. “As a result, the total average score of every indicator illustrates the ranking for every specific category” (Hubbard et al. 2009). The aggregation of all categories illustrates the overall sustainable performance index (Hubbard et al. 2009).

6. Conclusions

Sustainability assessment process provides the essential tools, indicators and operational framework in order to support urban sustainability design-makers, to affect the policy-makers and communicate to relevant stakeholders the actions and future visions towards the progress of urban sustainability. In addition, any sustainability assessment method is used to monitor the interactions and simultaneously measure the impacts of the three sustainability pillars integrated into existing policies, plans, legislations and projects, at a local or global scale.

Any sustainability assessment process (tools, methods or indicators) consists of specific fundamental elements, i.e.: i) interpreting sustainability, ii) measuring impact and structuring information and iii) affecting the decision-making process regarding sustainable development. The purposes of sustainability assessment tools, methods and indicators are the following:

1. Functionality of sustainable development, being adopted and applied for a particular regional or global system, within a certain socioeconomic and environmental framework.
2. Generation and communication in a transparent way all the essential sustainability information and outcomes, in a well-organized operational framework, assisting the decision-making process, supporting policy makers while demonstrating comparisons at local or global scale.
3. Simplicity of continuous communication among the various social groups of stakeholders, such decision-makers, policy-makers and local authorities and citizens.
4. Specification of knowledge and data gaps.

Every urban assessment indicator should be flexible and specific, being able to integrate the concepts of sustainable development. As a result, they contribute to the direct selection of appropriate design-making actions for the success of urban sustainability policy. However, there is no need for the comprehensive indicators to involve neither the commitment nor the compliance of designers and planners, which may have adverse impact upon the achievement of urban sustainability.

A look at the constant development of urban sustainability assessment processes demonstrates that there is an increasing trend, regarding progress towards fulfilling sustainable development. The increasing trend of understanding the sustainable development affects positively its applicability and its usefulness has become more accepted. In the recent years, the great recognition and acceptance globally led to the increase of the number of assessment methods, tools and indicators (see Appendix, Table I and Table II). In addition, the existence of even more assessing technologies contributes to boom the available sustainability assessment processes.

As the number of the available sustainability assessment processes increases, some classifications have become much more necessary than they were in the past while there is an increasing trend for the development of further assessment procedures in the foreseeable future. The present dissertation presents an analytical classification of sustainability assessment methods, tools and indicators, operating as generic, strategic or integrated assessment processes, which contribute to sustainability assessment and environmental ranking systems, accompanied with the related credit weighting tools, limitations and future suggestion plans.

Through a review of the main and sub-indicators of assessment tools, it has been recognized that some indicators are contained explicitly or implicitly within all sustainability assessment processes, although they are according to local conditions and they do not have the same weight or weighting points. Hence, such indicators can be called common indicators of significance resulting from their repetition in all global tools. Examples of such indicators include energy, water, waste, transport, sustainable buildings, etc.

Finally, the importance of every assessment tool, method and indicator varies and depends on the different factors and conditions that occurred each time. However, all the assessment processes constantly depend on the main factor, which is to structure a sustainability assessment framework in order to fulfill the needs of urban design and development, demanding comprehensiveness of all kinds of indicators. In addition, the existence of quantitative and qualitative indicators demonstrates the degree of credibility, which incur in the relationship between the main and sub-indicators.

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Appendix

Table I: Sustainability assessment methods, tools, and procedures (Poveda et al. 2011).

1. Analysis of Interconnected Decision Areas (AIDA) [1]
2. Analytic Hierarchy Process (AHP) [1]
3. ASSIPAC (Assessing the Sustainability of Societal Initiatives and Proposed Agendas for Change) [1]
4. ATHENA[1]
5. BEAT 2002[2]
6. BeCost (previously known as LCA-house) [2]
7. BEPAC (Building Environmental Performance Assessment Criteria) [1]
8. BRE Environmental Assessment Method (BREEAM) [1]
9. BRE Environmental Management Toolkits[1]
10. Building Energy Environment (BEE 1.0) [1]
11. Building Environmental Assessment and Rating System (BEARS) [1]
12. Building for Economic and Environmental Sustainability (BEES 2:0) [1]
13. CASBEE[2]
14. Cluster Evaluation[1]
15. Community Impact Evaluation[1]
16. Concordance Analysis[1]
17. Contingency Valuation Method[1]
18. Cost Benefit Analysis[1]
19. DGNB[2]
20. Eco-Effect[1]
21. Eco-Indicator 95[1]
22. Eco-Instal[1]
23. Economic Impact Assessment[1]
24. Ecological Footprint[1]
25. Eco-points [1]
26. Ecopro[1]
27. Eco-Profile[1]
28. EcoProP[1]
29. Eco-Quantum[1]
30. EIA – Environmental Impact Analysis[1]
31. ENVEST[1]
32. Environmental Profiles[1]
33. Environmental Status Model (Miljostatus) [2]
34. EQUER[1]
35. ESCALE[1]
36. Financial Evaluation of Sustainable Communities (FESC)[1]
37. Flag Model[1]
38. Green Building Challenge, changed in Sustainable Building (SB) Tool[1]
39. Green Globes[2]
40. Green Guide to Specification[1]
41. Green Start[2]
42. GRIHA[2]
43. Hedonic Analysis[1]
44. HKBEAM[2]
45. Hochbaukonstruktionen nach okologischen Gesichtspunkten (SIA D0123) [1]
46. INSURED[1]
47. LEEDTM (Leadership in Energy and Environmental Design Green Building Rating System) [1]
48. LEGEP (previously known as Legoe)
49. Life Cycle Analysis (LCA) [1]
50. Mass Intensity Per Service Unit (MIPS) [1]
51. MASTER Framework[1]
52. Meta Regression Analysis[1]
53. Multi-Criteria Analysis[1]
54. NABERS[2]

(continued) Table I: Sustainability assessment methods, tools, and procedures (Poveda et al. 2011).

55.	Net Annual Return Model[(1)]
56.	OGIP (Optimierung der Gesamtanforderungen ein Instrument fur die Integrale Planung) [(1)]
57.	PAPOOSE[(1)]
58.	PIMWAQ[(1)]
59.	Project Impact Assessment[(1)]
60.	Regime Analysis[(1)]
61.	SBTool 2005[(2)] (formerly known as GBTool)
62.	Quantitative City Model[(1)]
63.	Planning Balance Sheet Analysis[(1)]
64.	Risk Assessment Method (s) [(1)]
65.	SANDAT[(1)]
66.	Semantic Differential[(1)]
67.	Social Impact Assessment[(1)]
68.	SPARTACUS (System for Planning and Research in Town and Cities for Urban Sustainability) [(1)]
69.	SEA (Strategic Environmental Assessment) [(1)]
70.	Sustainable Cities[(1)]
71.	Sustainable Regions[(1)]
72.	Transit-oriented Settlement[(1)]
73.	Travel Cost Theory[(1)]

Table II: Tools included in the "Sustainability A - Test" EU project (Poveda et al. 2011).

Group	Sustainable Development Tool (Methodologies, models, approaches and appraisals)
Assessment Frameworks	EU impact assessment system Environmental impact assessment Strategic environmental assessment Integrated Sustainability Assessment / Transition Management
Participatory Tools	Electronic focus groups Tools to inform debates, dialogues & deliberations Consensus conference Repertory grid technique Interactive backcasting Focus group Delphi Survey In-depth interviews Citizen`s Jury
Scenario Analysis	Trends Cross Impact Relevance trees and morphologic analysis Modeling, simulating, training Interactive brainstorming Scenario workshops Integrated foresight management model Ranking method
Multi-criteria Analysis	Multi-attribute value theory Weighted Summation Analytic hierarchy process Preference ranking organization method for enrichment evaluations Novel approach to imprecise assessment and decision environments REGIME Dominance method Software for MCA
Cost-benefit Analysis and Cost-effectiveness Analysis	Cost-benefit analysis Travel costs Hedonic pricing Cost of illness Contingent valuation Averting expenditures Contingent behavior Market methods Conjoint choice questions Cost-effectiveness analysis
Modeling Tools	Family of socio-economic models General economy models Demographic models Public health models Partial economic models Family of bio-physical models Climate models Biogeochemistry models Hydrology models Family of integrated models Land use models Integrated assessment models Qualitative system analysis models Scenario building and planning tools
Accounting Tools, Physical Analysis Tools and Indicator Sets	Measure of economic welfare Sustainable national income Genuine savings National accounting matrix including environmental accounts Index of sustainable economic welfare Ecological footprint Global land use accounting Economy-wide MFA Lifecycle assessment Indicator sets for assessments Vulnerability Assessment: Livelihood sensitivity approach

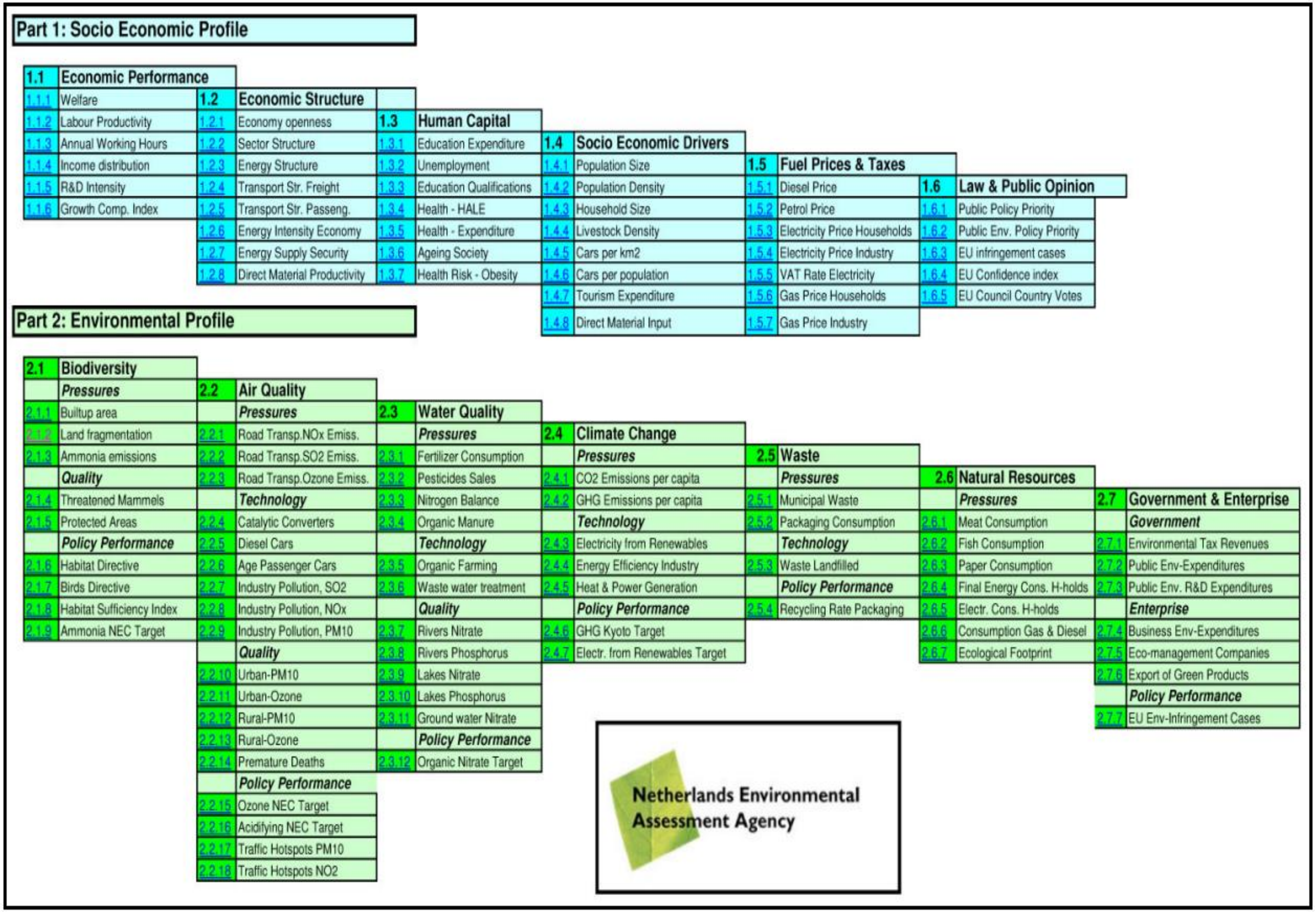

Figure I: Overview of MNP European Benchmarking Indicators (EBI) (Vixseboxse et al. 2007).